Tree Farm License 49

Documentation of Analysis for Vegetation Resources Inventory Statistical Adjustment

PREPARED BY:

MINISTRY OF SUSTAINABLE RESOURCE MANAGEMENT

RESOURCES INVENTORY DEPARTMENT

TERRESTRIAL INFORMATION BRANCH

FOREST RENEWAL BC

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EXECUTIVE SUMMARY

This report documents the Vegetation Resources Inventory (VRI) ground sample inventory analysis that was completed for Riverside Forest Products' Tree Farm License 49.

This analysis focused on the development of adjustment factors for height, age and volume to support the current timber supply analysis. The process used to derive these adjustments is interim (Fraser protocol) and may change in the future. In the "Fraser Protocol", the statistical adjustment of inventory attributes consists of a set of steps and assumptions used to develop and then apply adjustment factors to the inventory file attributes of height and age and the volume predicted using VDYP. The goal of the adjustment is to remove any overall bias in the inventory when compared against the VRI ground data for the attributes that are adjusted.

The steps in this adjustment process are :

1. Adjust height and age.
2. Based on the adjusted height and age, use VDYP to computed inventory volume (attribute - adjusted inventory volume)
3. Use the compiled ground volumes to then adjust the "attribute-adjusted" inventory volume.

The information contained in this report is "draft", however it is expected that this information will be used to adjust the VRI photo based inventory database files for the upcoming timber supply analysis.

The stakeholders original sampling objectives were to check and improve the accuracy of the timber inventory in the TFL using a VRI timber emphasis inventory. The number of samples was designed to achieve a target sampling error of +- 10% (95% probability) for net merchantable volume (volume utilization was: 12.5cm+ dbh net dwb) in the treed mature portion (stratum 1) of the TFL. The database was sampled using the ordered systematic system, with the sample list generated from the new VRI standard photo-interpretation inventory. Two sampling strata were identified. Stratum 1 consisted of mature polygons in the population (80 + years). Stratum 2 consisted of the remaining polygons (treed immature and non-treed).

A total of 87 timber emphasis samples were established within the TFL 49 landbase, 78 were used for this analysis. (67 plots were used in stratum 1 (mature) and 18 in strata 2 (immature)).

Net volume adjustment factor sampling (NVAF) was completed in this unit with a total of 46 live and 10 dead trees destructively sampled.

The overall strata results indicate:

i) *Mature stratum*: the overall net factoring / NVAF derived volume ratio was 1.048 with a sampling error of 10.47%. Overall height and age ratios of 0.974 and 0.998 were reported.

ii) Immature strata: the overall net factoring / NVAF derived volume ratio of 1.875 with a sampling error of 46%. Overall height and age ratios of 1.686 and 1.825 were reported.

The results provided an all species live tree NVAF ratio of 0.88 with a 9% sampling error (95%) of the ratio and a dead tree NVAF ratio of 1.02 with a 24% sampling error of the ratio.

Further analysis by species strata and age are summarized in this report.

At this time, the final decision on the most suitable factors for adjustment have not been finalized. This report does not provide a summary or a check of the impacts of these adjustments against the inventory files.

The total contract costs to date on this project are approximately $ 170,000 for field sampling and $10,000 for planning and analysis.

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1. INTRODUCTION

1.1 Background

This is the final VRI ground sample inventory analysis report completed by Terrestrial Information Branch (TIB) of the Ministry of Sustainable Resource Management (MSRM) for Riverside Forest Products' Tree Farm License 49 (TFL 49).

The material presented in this report was made available for the current Timber Supply Review (TSR) and was developed in conjunction with staff from the MSRM, TIB, Kamloops Forest Region and Ministry of Forests, Timber Supply Branch. Funding was largely provided by Riverside Forest Products through Forest Renewal. Analysis support was provided by Jahraus and Associates Ltd.. Timberline Forest Inventory Consultants Ltd. provided analysis co-ordination and review.

The report references and contains content from the previously developed "Tree Farm License 49 Vegetation Resource Inventory, Timber Emphasis Inventory Ground Sample Sampling Plan, Final Report Sept 30, 1997. A copy of this document is available from Terrestrial Information Branch.

The original sampling objectives were to check and improve the accuracy of the timber inventory in the TFL using a VRI timber emphasis inventory. The number of samples was designed to achieve a target sampling error of +- 10% (95% probability) for net merchantable volume in the vegetated treed (VT) mature portion > 80 years of age (stratum 1) of the TFL. A second population consisting of immature VT, <=80 years of age and non-VT, all ages (referred to as the "immature" stratum) was also sampled.

Net volume adjustment factor sampling (NVAF) was completed in this unit. A total of 46 live and 10 dead trees were destructively sampled.

The database was sampled using ordered systematic sampling, with the sample list generated from the new VRI standard photo-interpretation inventory.

1.2 Scope and Objectives

The objective of this analysis was to provide statistical adjustment factors for the TFL 49 VRI in support of the upcoming Timber Supply Review. The application of the adjustment factors to the inventory files and the subsequent checks are outside the scope of the MSRM analysis.

2. METHODS

2.1 Overview of statistical adjustment

Statistical adjustment is the process of adjusting the values of the photo-interpreted variables in the inventory using information from the ground sampling observations. The statistical adjustment factors for TFL 49 were developed using the current MSRM approach known as the "Fraser Protocol".

In the Fraser Protocol, ground observations are compared with photo-estimated values[1] for each sampled polygon. A statistical model, typically ratio of means[2], is then used to develop the adjustment factors.

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[1] In VRI terminology, the ground sample values are referred to as PHASE II values and the photo-interpreted inventory values are referred to as PHASE I values.

These factors are applied to all polygons in the photo-interpreted inventory database to produce the final adjusted inventory database. Under the current MSRM minimum standard, only three inventory attributes are adjusted: age, height and volume. The Fraser Protocol is a sequential approach where adjustment factors for inventory age and height are computed first, a new "attribute-adjusted" inventory volume (based on the adjusted age and height) is calculated next, and finally, a volume adjustment factor is computed based on the "attribute-adjusted" inventory volume. This process is shown diagrammatically in Figure 1 below.

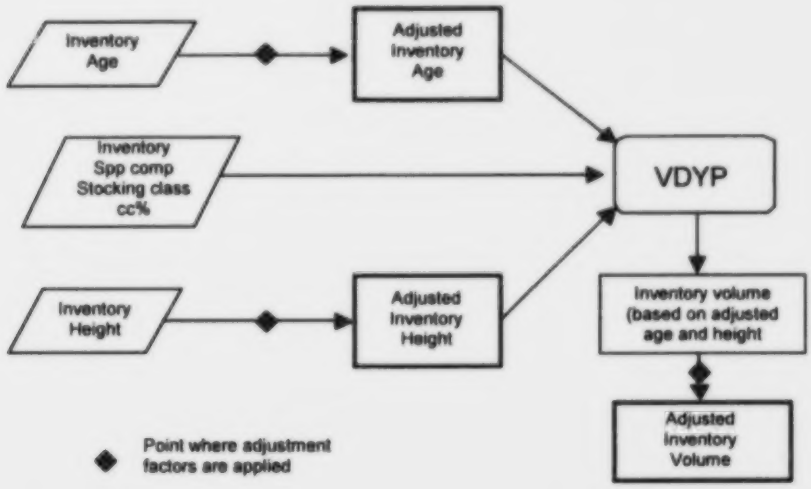

Figure 1: Overview of the Fraser Protocol for statistical adjustment of inventories.

2.2 Population for adjustment

The original objective was to adjust the mature stratum, that is, the vegetated treed population greater than 80 years of age. Adjustments to the immature strata were to be considered within the context of analysis results.

2.3 Data sources

2.3.1 Phase I photo-interpreted inventory data

Ground sample analysis was based on the most recent set of Vegcap[3] editted inventory files provided by TIB. [4] When the attributes based on this "new" inventory data were examined, two samples[5] originally

[2] Ratio-of-means is generally appropriate if the relationship between **y** (ground attribute, in this case) and **x** (inventory attribute) is linear and passes through the origin. If these conditions are not met alternative adjustment approaches (such as linear regression, geometric mean regression, non-linear regression) may be explored. However, these alternatives also have their limitations and may produce undesirable characteristics in the adjusted population.

[3] VEGCAP: VRI phase 1 edit program.

identified as being in the mature stratum moved to the immature stratum (based on the age identified in the inventory). These samples were reassigned to the immature stratum for the development of the adjustment factors.

Both of these samples were from multi-layered stands. It was determined that this change in stratum membership was a result of the incorrect layer being used for the original selection file. Further examination of this issue showed that only 5% of TFL 49 was multi-layered stands. *No special weighting was applied to account for this change in stratum assignment for these 2 samples.*

Inventory data was projected to 1998 (year of the majority of the ground sampling) for this analysis.

2.3.2 Phase II ground sample data

Ground sample data was compiled using most recent version of VRI compiler. Outputs included NVAF derived volumes.[6]

Data issues related to the analysis

Samples #76 and #102 were excluded from the analysis since they were recently logged.

2.4 Data matching

For each VRI sample polygon, the ground sample data was matched with the corresponding inventory data for the same polygon. The ground and inventory data used in the development of the adjustment factors for the TFL 49 are provided in Appendix A.

The ground heights and ages used in the adjustment were based on the average values for the T, S & L[7] trees for the leading species (by basal area at 4cm + dbh utilization) on the ground. In the Vegetation Inventory File (VIF) format, inventory data (i.e. height and age) is available for the leading and second species. The objective in the matching process was to choose an inventory height and age (i.e. for either the leading or second species) so that the ground and inventory species "matched". If a match could not be made at the sp0[8] level, conifer-to-conifer matches were allowed. However, conifer-deciduous matches were not considered acceptable. Details of the species matching process, included a description of 7 possible "cases" for matching, are provided in the VRI Draft Attribute Adjustment Procedures document available from the MSRM.

A total of 63 of the 85 samples available were matched at the leading species or sp0 level[9]. A further 13 samples could be matched using the second species[10]. Eight samples were based on conifer-to-conifer

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[4] Inventory file data (MDBs) was provided by Gary Johansen and Tim Salkeld TFL49_inv.dbf. Received November 23, 2001

[5] Samples #52 and #55.

[6] Dec 18,2001

[7] T or "top height" tree is the largest DBH in 0.01 ha plot, regardless of species; L or "leading species" tree is the largest DBH in 0.01 ha plot, of leading species; S or "second species" is the largest DBH in 0.01 ha plot, of second species. T and S trees are selected and measured at the IPC only whereas L trees are selected at the IPC and all auxiliary plots. For details, refer to Section 4.8 in the MSRM document "VRI Ground Sampling Procedures". January 2001 version 4.2.

[8] sp0 refers to the 16 major species codes and is roughly equivalent to the genus level.

[9] 58 samples were matched based on "Case 1" and a further 5 samples matched based on "Case 3".

matches[11]. One sample had no leading species at 4cm+ dbh on the ground and hence could not be matched.

2.5 Pre-stratification and sub-stratification

The population was pre-stratified into a mature and an immature stratum as described below:

- VT, >80 years of age (referred to as the "mature" stratum)
- VT, <=80 years of age and non-VT, all ages (referred to as the "immature" stratum).

The analysis and the development of the adjustment factors maintained this sampling pre-stratification. In addition, further sub-stratification based on species groupings and age groupings was investigated in the mature stratum. Because of the limited sample size and variability, no sub-stratification was proposed for the immature stratum.

Examination of the mature stratum adjustment ratios and scatter plots revealed that trends in the ground to inventory relationships appeared to differ by inventory leading species group and age. The leading species groups defined were:

- Spruce or balsam leading
- Douglas-fir leading
- Lodgepole pine leading

Age sub-stratification was based on a 120 year age break (i.e. inventory age <121 and inventory age >120).

3. RESULTS AND DISCUSSION

3.1 Age and height adjustment

See tables in draft adjustment factors documents:

"VRI Adjustment Factors for TFL 49 – Jan 02-02.doc"

"Alternative adjustment factors for TFL 49 – Apr3-02.doc"

3.2 Volume adjustment

Volume adjustment factors were produced based on loss factor (LF) and net volume adjusted (NVAF) compiled volumes. All compiled volumes used in the adjustment reflect utilization at 12.5 cm+ net dwb.

The volume adjustment is based on the Fraser Protocol, hence the volume adjustment ratios provided in the table below are intended to be applied to VDYP volumes produced after height and age have been adjusted using the factors in Table 1.

See tables in the documents:

"VRI Adjustment Factors for TFL 49 – Jan 02-02.doc"

"Alternative adjustment factors for TFL 49 – Apr3-02.doc"

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[10] 9 samples were matched based on "Case 2" and a further 4 samples matched based on "Case 4".

[11] These 8 samples represent "Case 5".

3.3 Overall volume impact

The overall volume impact was assessed by comparing the ground-compiled volume with the unadjusted inventory volume. It represents the potential volume impact that the adjustment suggested here would have on the current inventory in TFL 49.

See tables in documents:

"VRI Adjustment Factors for TFL 49 – Jan 02-02.doc"

"Alternative adjustment factors for TFL 49 – Apr3-02.doc"

Sampling error at the 95% confidence level is also shown in these documents.

4. RECOMMENDATIONS

The licensee should review this analysis and provide a recommendation on the most appropriate use of this information. It is expected that the leading species/age related strata for the mature stratum will be used for adjustment. The net factoring / NVAF volume adjustment factors meet current MSRM standards. Due to the high sampling error, small sample size and poor correlation in the immature strata, adjustments to this component of the inventory should be carefully considered. Following the adjustments to the inventory files the licensee should provide documentation to ensure the adjustments were correctly applied.

5. APPENDIX A: GROUND AND INVENTORY DATA

January 2, 2002 DRAFT

Table 1: Age and Height Ratios for Strata Option 1 (calculated ignoring spp strata)

Stratum	n	Ground height	Map height	Height ratio	n	Ground age	Map age	Age ratio
Mature	63	23.66	24.283	0.974	63	149.032	149.397	0.998
Immature	15	14.22	8.433	1.686	15	67.533	37	1.825

Table 2: Age and Height Ratios for Strata Option 2

Stratum		n	Ground height	Map height	Height ratio	n	Ground age	Map age	Age ratio
Mature	SB	17	26.918	27.094	0.994	17	187.059	195.529	0.957
	FD	23	21.93	24.213	0.906	23	141.348	142.565	0.991
	PL	23	22.983	22.274	1.032	23	128.609	122.13	1.053
Immature		15	14.22	8.433	1.686	15	67.533	37	1.825

Table 3: Volume Ratios for Strata Option 1 (calculated ignoring spp strata)

Stratum	n	Ground NVAF vol/ha	Ground LF vol/ha	Unadjusted Inventory vol/ha	Attribute-adjusted inventory vol/ha	Overall NVAF volume impact	Overall LF volume impact	Volume adjustment ratio (NVAF)
Mature	67	258.936	272.821	247.100	232.963	1.048±3.47% [12]	1.104±10.81%	1.111
Immature	18	83.406	93.553	44.472	123.639	1.875±44.6%	2.104±45.9%	0.675

Table 4: Volume Ratios for Strata Option 2

Stratum		n	Ground NVAF vol/ha	Ground LF vol/ha	Unadjusted Inventory vol/ha	Attribute-adjusted inventory vol/ha	Overall NVAF volume impact	Overall LF volume impact	Volume adjustment ratio (NVAF)
Mature	SB	19	350.298	361.129	298.316	292.174	1.174±17.9%	1.211±18.2%	1.199
	FD	24	174.085	191.264	188.829	156.283	0.922±27.1%	1.013±27.2%	1.114
	PL	24	271.458	284.467	264.825	275.483	1.025±14.9%	1.074±15.2%	0.985
Immature		18	83.406	93.553	44.472	123.639	1.875±44.6%	2.104±45.9%	0.675

[12] Sampling error is reported as a percentage of the ratio. All sampling error have been computed at the 95% probability level.

6. SCATTERPLOTS FOR HEIGHT AND AGE ADJUSTMENT BASED ON STRATA OPTION 1

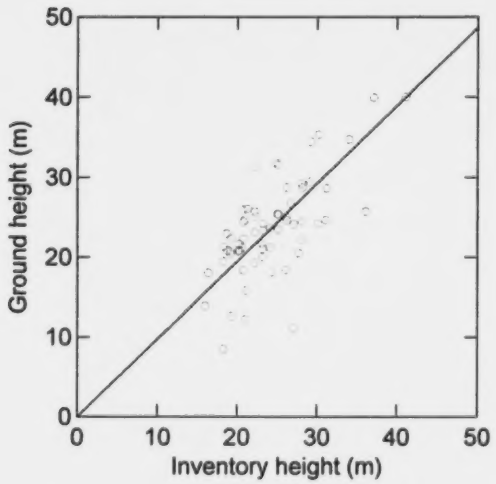


Fig. 1: Ground height versus inventory height for mature stratum. Line represents adjustment ratio.

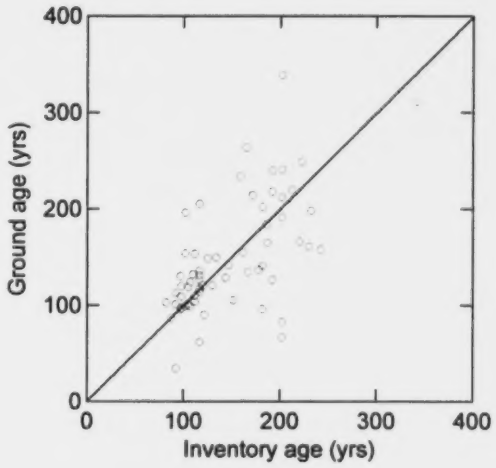


Fig. 2: Ground age versus inventory age for mature stratum. Line represents adjustment ratio.

7. SCATTERPLOTS FOR HEIGHT AND AGE ADJUSTMENT BASED ON STRATA OPTION 2

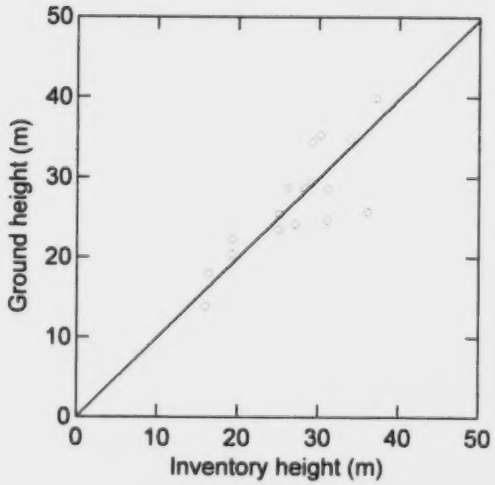


Fig. 3: Ground height versus inventory height for mature stratum, SB leading. Line represents adjustment ratio.

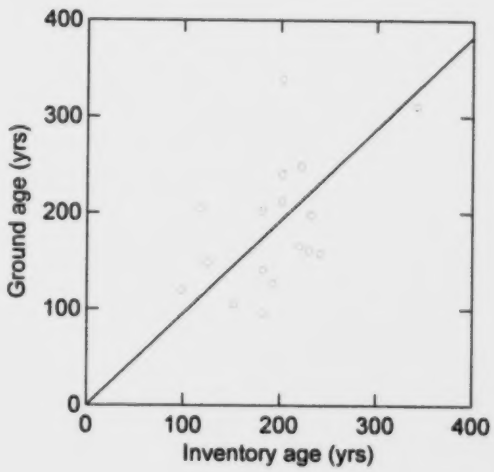


Fig. 4: Ground age versus inventory age for mature stratum, SB leading. Line represents adjustment ratio.

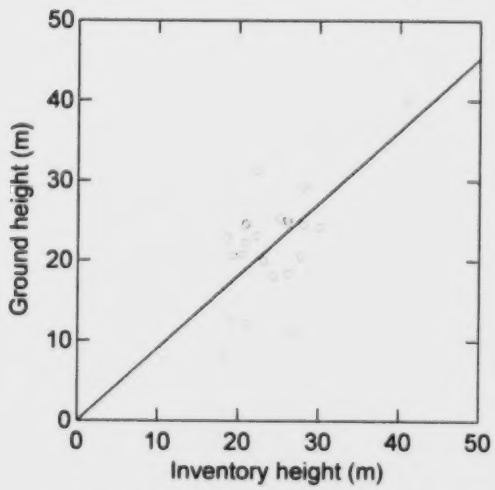


Fig. 5: Ground height versus inventory height for mature stratum, Fd leading. Line represents adjustment ratio.

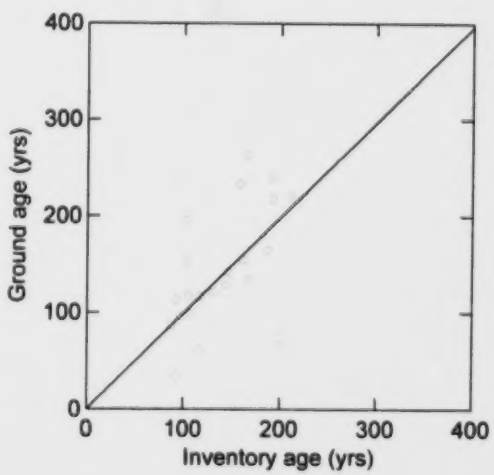


Fig. 6: Ground age versus inventory age for mature stratum, Fd leading. Line represents adjustment ratio.

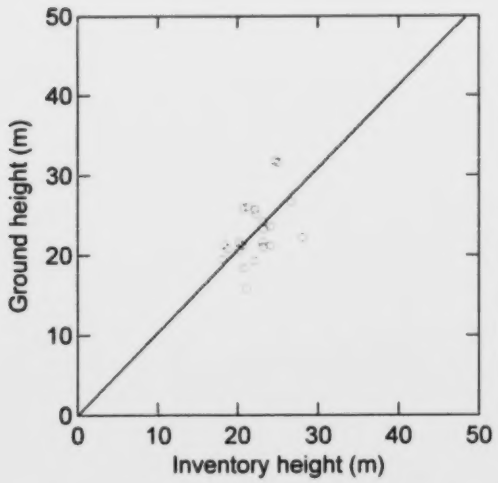


Fig. 7: Ground height versus inventory height for mature stratum, PI leading. Line represents adjustment ratio.

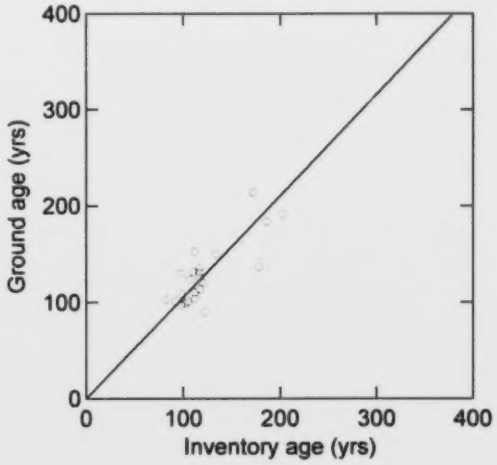


Fig. 8: Ground age versus inventory age for mature stratum, PI leading. Line represents adjustment ratio.

8. SCATTERPLOTS FOR VOLUME ADJUSTMENT BASED ON STRATA OPTION 1

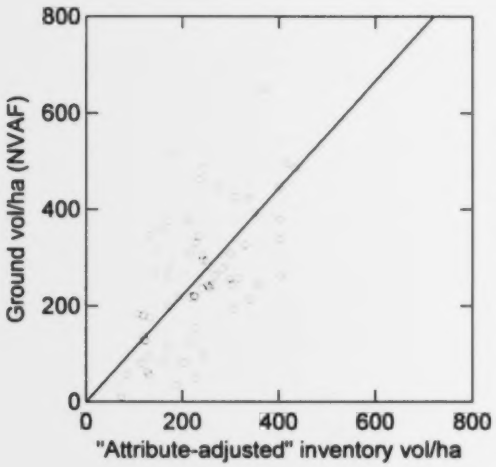


Fig. 9: Ground vol/ha versus "attribute-adjusted" inventory vol/ha for mature stratum. Volume utilization is 12.5cm+ dbh net dwb. Ground volume is compiled with NVAF. Line represents adjustment ratio.

9. SCATTERPLOTS FOR VOLUME ADJUSTMENT BASED ON STRATA OPTION 2

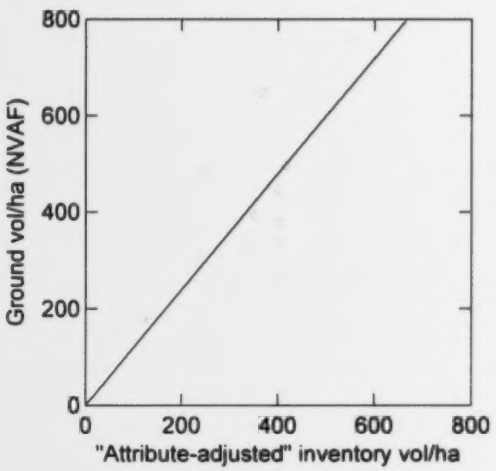


Fig. 10: Ground vol/ha versus "attribute-adjusted" inventory vol/ha for mature stratum, SB leading. Volume utilization is 12.5cm+ dbh net dwb. Ground volume is compiled with NVAF. Line represents adjustment ratio.

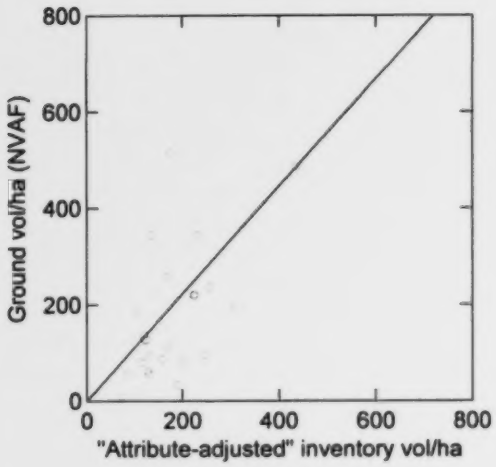


Fig. 11: Ground vol/ha versus "attribute-adjusted" inventory vol/ha for mature stratum, Fd leading. Volume utilization is 12.5cm+ dbh net dwb. Ground volume is compiled with NVAF. Line represents adjustment ratio.

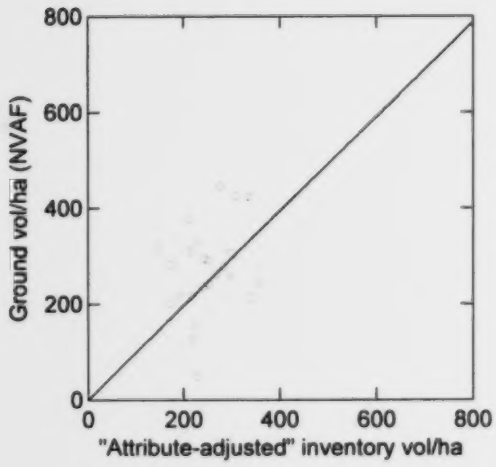


Fig. 12: Ground vol/ha versus "attribute-adjusted" inventory vol/ha for mature stratum, Pl leading. Volume utilization is 12.5cm+ dbh net dwb. Ground volume is compiled with NVAF. Line represents adjustment ratio.

10. SCATTERPLOTS FOR OVERALL VOLUME IMPACT BASED ON STRATA OPTION 1

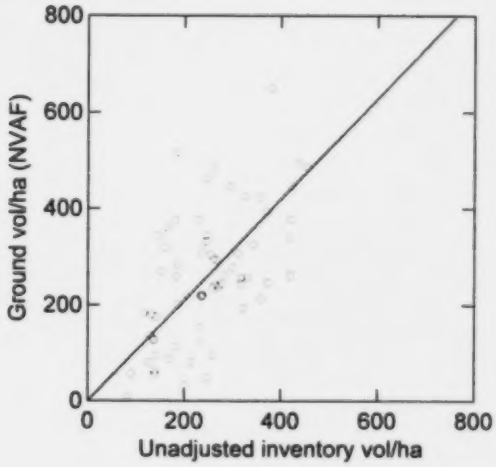


Fig. 13: Ground vol/ha versus unadjusted inventory vol/ha for mature stratum. Volume utilization is 12.5cm+ dbh net dwb. Ground volume is compiled with NVAF. Line represents overall volume impact ratio.

11. SCATTERPLOTS FOR OVERALL VOLUME IMPACT BASED ON STRATA OPTION 2

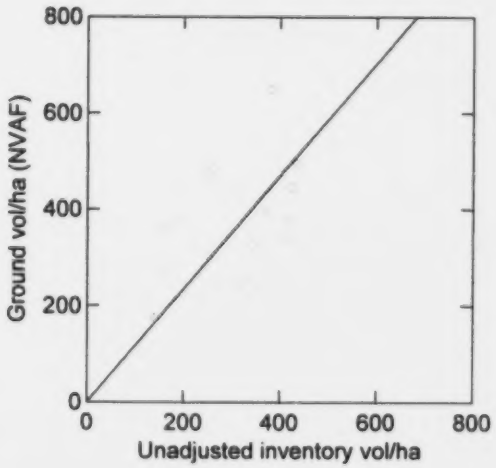


Fig. 14: Ground vol/ha versus unadjusted inventory vol/ha for mature stratum, SB leading. Volume utilization is 12.5cm+ dbh net dwb. Ground volume is compiled with NVAF. Line represents overall volume impact ratio.

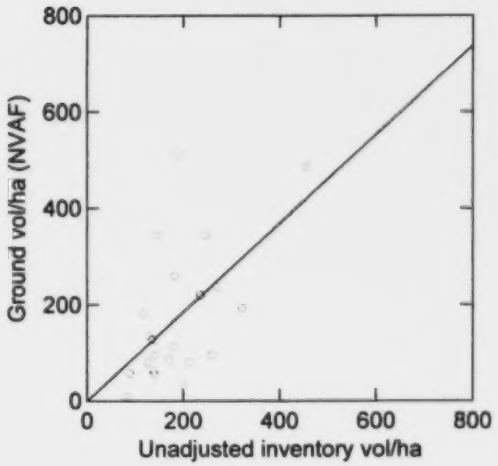


Fig. 15: Ground vol/ha versus unadjusted inventory vol/ha for mature stratum, Fd leading. Volume utilization is 12.5cm+ dbh net dwb. Ground volume is compiled with NVAF. Line represents overall volume impact ratio.

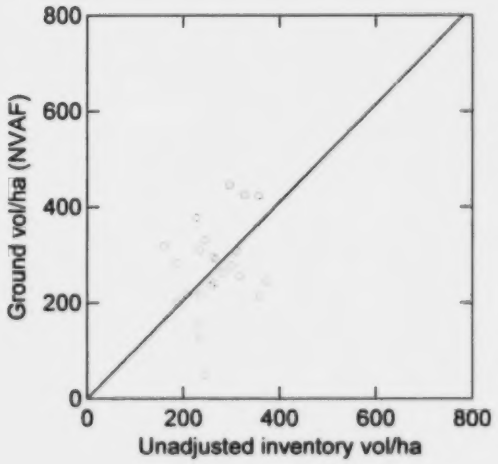


Fig. 16: Ground vol/ha versus unadjusted inventory vol/ha for mature stratum, Pl leading. Volume utilization is 12.5cm+ dbh net dwb. Ground volume is compiled with NVAF. Line represents overall volume impact ratio.

12. RESIDUALS PLOTS FOR HEIGHT, AGE & VOLUME BASED ON STRATA OPTION 1

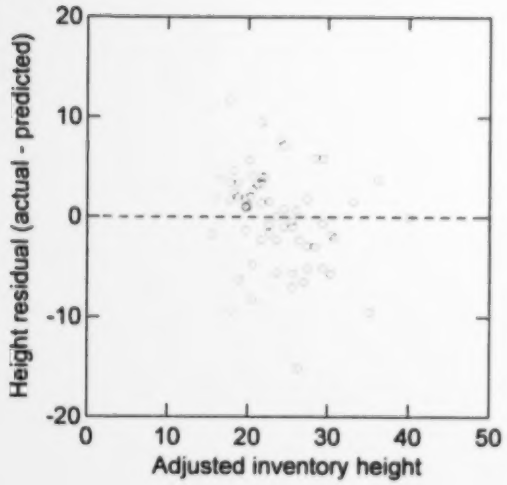


Fig. 17: Height residual (ground height – adjusted inventory height) vs. adjusted inventory height for mature stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

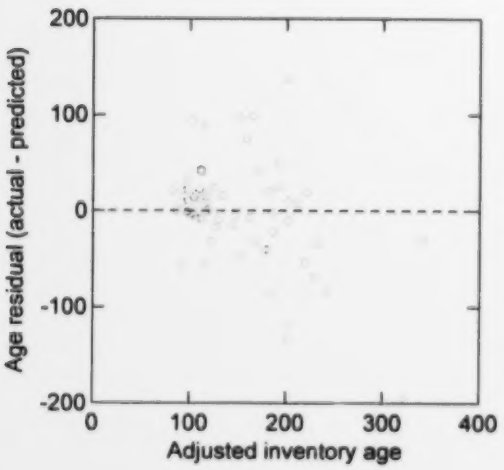


Fig. 18: Age residual (ground age – adjusted inventory age) vs. adjusted inventory age for mature stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

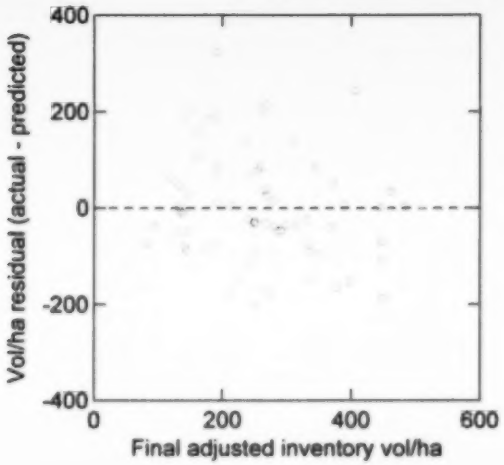


Fig. 19: Volume residual (ground volume – adjusted inventory volume) vs. adjusted inventory volume for mature stratum. Horizontal line represents zero bias. Points above the line represent underestimates whereas points below the line represent overestimates.

13. APPENDIX A: GROUND AND INVENTORY DATA

Alternative VRI Adjustment Factors for TFL 49 April 3, 2002

CHANGES TO MARCH 21/02 VERSION:

- *Sampling error (at 95%) for overall volume impact added to tables 6 and 8*
- *Captions for figures 5-8 corrected to read "height" instead of "volume"*

Analysis Notes:

- Please refer to the previously distributed document entitled "VRI Adjustment Factors for TFL 49 – Jan 02-02.doc" for analysis assumptions, volume utilization, etc.
- This analysis provides two additional alternative sets of adjustment factors (Options 3 and 4). Each of the 4 options that have been presented (in this document and in the January 02/02 document) are defined below:

  Option 1: Separate sets of adjustment factors are produced for each of the mature and immature strata. These strata were defined when the original population was pre-stratified for sampling.

  Option 2: The mature stratum (see option 1) is substratified into 3 leading species groups and a set of adjustment factors is provided for each of these species substrata. In addition, a single set of adjustment factors is provided for the immature stratum (with no further substratification) as in Option 1.

  Option 3: The data from the mature and immature strata are combined to produce a set of single adjustment factors that would be applied to all data (i.e. mature and immature polygons would have the same adjustment factor applied). Formulae for combined ratio estimators (which take into account the relative areas of the strata being combined) are used to produce the adjustment factors.

  Option 4: The mature leading species substrata in Option 2 are further substratified using a 120 year age break. As in Option 2 there is no substratification applied to the immature stratum.

- Note that in Option 4, sample size becomes an issue in some substrata (most notably the SB, <121 yrs substrata).
- Figures 1 to 8 provide a graphical comparison of the four stratification options. One set of graphs looks at trends in bias for adjusted volume as a function of age. The second set of graphs looks at trends in bias for adjusted height as a function of age. Age-related bias is most prominent with Option 3 where the immature and mature strata are combined into a single adjustment factor.

Option 3[13]

Adjustment based on a single combined ratio estimate from mature and immature strata

Table 5: Age and Height Ratios based on a single combined ratio estimate from mature and immature strata (option 3)

Stratum		n	Ground height	Map height	Height ratio	n	Ground age	Map age	Age ratio
Mature	85272.85	63	23.66	24.283	1.094	63	149.032	149.397	1.101
Immature	49368.02	15	14.22	8.433		15	67.533	37	

Table 6: Volume Ratios based on a single combined ratio estimate from mature and immature strata (option 3)

Stratum		n	Ground NVAF vol/ha	Grd LF vol/ha	Unadjusted Inventory vol/ha	Attribute-adjusted inventory vol/ha (based on table 5)	Overall NVAF volume impact	Overall LF volume impact	Volume adjustment ratio (NVAF)	Volume adjustment ratio (LF)
Mature	85272.85	67	258.93576	272.821	247.1	280.648	***1.126 ± 10.6%***	***1.198 ± 11.1%***	0.994	1.058
Immature	49368.02	18	83.40611	93.553	44.472	49.272				

[13] Options refer to post-stratification alternatives. Option 1 (presented in January 2/02 draft) is based on separate factors for mature and immature strata (i.e. corresponds with pre-stratification). Option 2 (presented in January 02/02 draft) is based on species substratification within the mature stratum. Option 3 (presented here) is based on a single adjustment factor (combined ratio estimation formulae used to combine the mature and immature strata). Option 4 (presented here) is a further substratification of Option 2 with age-based substrata with the species substrata.

Option 4

Adjustment based on age within species substrata within the mature stratum (ratios for species substrata – with no age breaks – are also shown)

Table 7: Age and Height ratios by age and species substrata (option 4)

Stratum		n	Ground height	Map height	Height ratio	n	Ground age	Map age	Age ratio
Mature	SB	17	26.918	27.094	0.994	17	187.059	195.529	0.957
	map age <121	***2***	***20.15***	***17.85***	***1.129***	***2***	***182.5***	***107.5***	***1.512***
	map age >120	***15***	***27.82***	***28.327***	***0.982***	***15***	***190.333***	***207.267***	***0.918***
	FD	23	21.93	24.213	0.906	23	141.348	142.565	0.991
	map age <121	***10***	***20.47***	***20.62***	***0.993***	***10***	***107.8***	***101.8***	***1.059***
	map age >120	***13***	***23.054***	***26.977***	***0.855***	***13***	***167.154***	***173.923***	***0.961***
	PL	23	22.983	22.274	1.032	23	128.609	122.13	1.053
	map age <121	***16***	***23.069***	***21.844***	***1.068***	***16***	***117.563***	***106.438***	***1.105***
	map age >120	***7***	***22.786***	***23.714***	***0.961***	***7***	***153.857***	***158***	***0.974***
Immature		15	14.22	8.433	1.686	15	67.533	37	1.825

Table 8: Volume Ratios by age and species substrata (option 4)

Stratum			n	Ground NVAF vol/ha	Grd LF vol/ha	Unadjusted Inventory vol/ha	Attribute-adjusted inventory vol/ha	Overall NVAF volume impact[14]	Overall LF volume impact	Volume adjustment ratio (NVAF)	Volume adjustment ratio (LF)
Mature	SB		19	350.29758	361.129	298.316	292.174	1.174 ±17.9%	1.211 ±18.2%	1.199	1.236
		map age <121	4	376.284	396.83	204.825	240.075	1.837 ±19.2%	1.937 ±17.3%	1.567	1.653
		map age >120	15	343.368	351.608	323.247	312.707	1.062 ±18.2%	1.088 ±18.2%	1.098	1.124
	FD		24	174.08508	191.264	188.829	156.283	0.922 ±27.1%	1.013 ±27.2%	1.114	1.224
		map age <121	11	168.941	187.102	141.545	136.173	1.194 ±51.8%	1.322 ±51.5%	1.241	1.374
		map age >120	13	178.438	194.786	228.838	174.685	0.780 ±28.1%	0.851 ±28.0%	1.021	1.115
	PL		24	271.45833	284.467	264.825	275.483	1.025 ±14.9%	1.074 ±15.2%	0.985	1.033
		map age <121	16	273.066	290.781	246.375	274.719	1.108 ±19.3%	1.180 ±19.1%	0.994	1.058
		map age >120	8	268.243	271.84	301.725	281.7	0.889 ±24.6%	0.901 ±24.6%	0.952	0.965
Immature			18	83.40611	93.553	44.472	123.639	1.875 ±44.6%	2.104 ±45.9%	0.675	0.757

[14] Sampling error is for a 95% probability level and is reported as a percentage of the ratio.

14. VOLUME RESIDUALS AS A FUNCTION OF UNADJUSTED INVENTORY AGE, BY STRATIFICATION OPTION

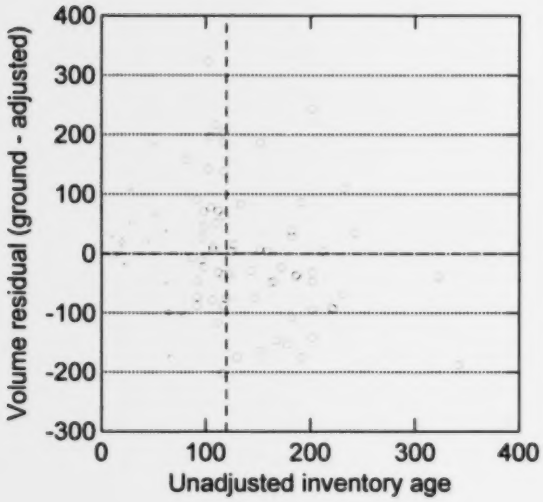


Fig 1: Volume residuals (ground vol/ha – adjusted inventory vol/ha) as a function of inventory age for adjustments based on **Option 1** (mature/immature) stratification. NOTE: **x**'s correspond to immature stratum samples and **o**'s correspond to mature stratum samples.

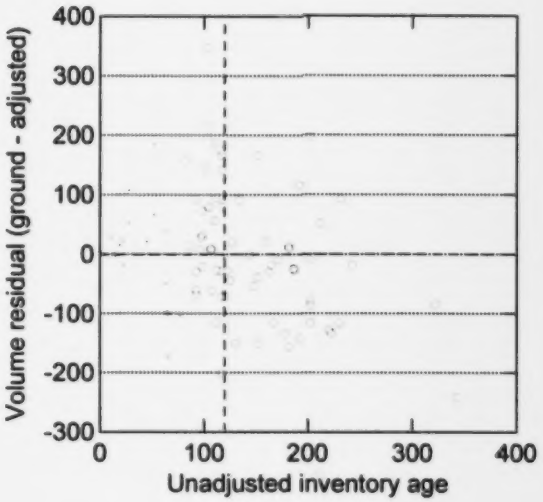


Fig 2: Volume residuals (ground vol/ha – adjusted inventory vol/ha) as a function of inventory age for adjustments based on **Option 2** (immature & species substratification within mature) stratification. NOTE: **x**'s correspond to immature stratum samples and **o**'s correspond to mature stratum samples.

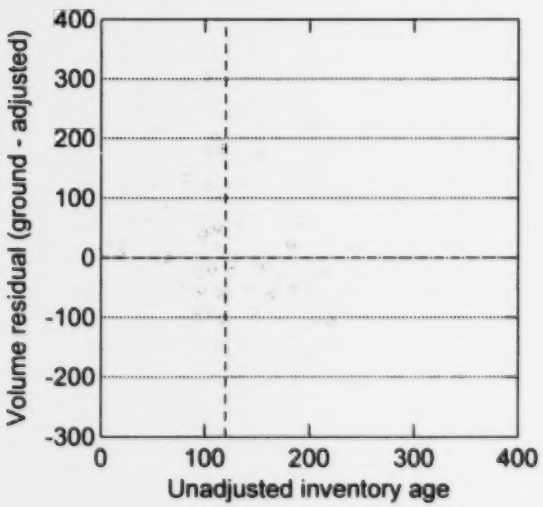


Fig 3: Volume residuals (ground vol/ha – adjusted inventory

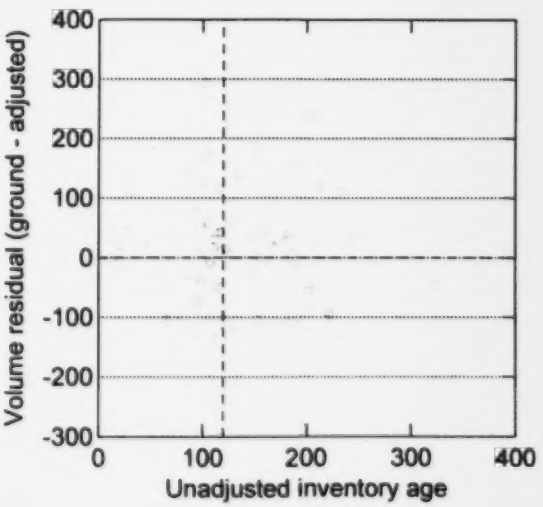


Fig 4: Volume residuals (ground vol/ha – adjusted inventory

vol/ha) as a function of inventory age for adjustments based on **Option 3** (single combined factor) stratification. NOTE: **x**'s correspond to immature stratum samples and **o**'s correspond to mature stratum samples.

vol/ha) as a function of inventory age for adjustments based on **Option 4** (immature & age within species substratification for mature) stratification. NOTE: **x**'s correspond to immature stratum samples and **o**'s correspond to mature stratum samples.

15. HEIGHT RESIDUALS AS A FUNCTION OF UNADJUSTED INVENTORY AGE, BY STRATIFICATION OPTION

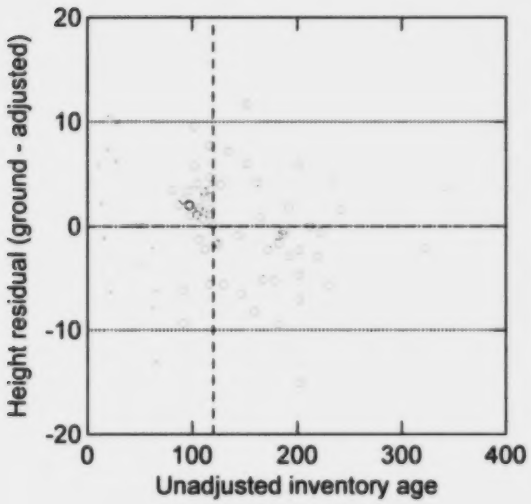


Fig 5: Height residuals (ground height – adjusted inventory height) as a function of inventory age for adjustments based on **Option 1** (mature/immature) stratification. NOTE: **x**'s correspond to immature stratum samples and **o**'s correspond to mature stratum samples.

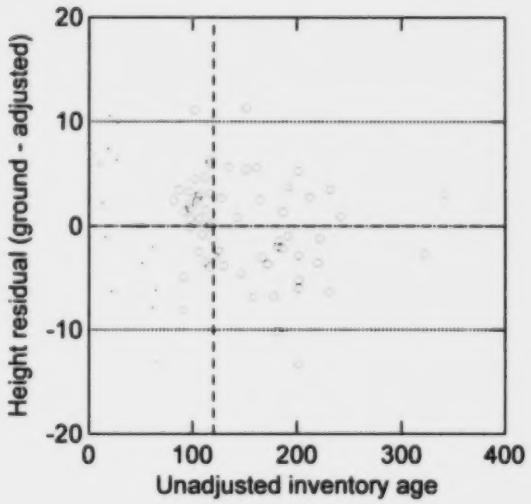
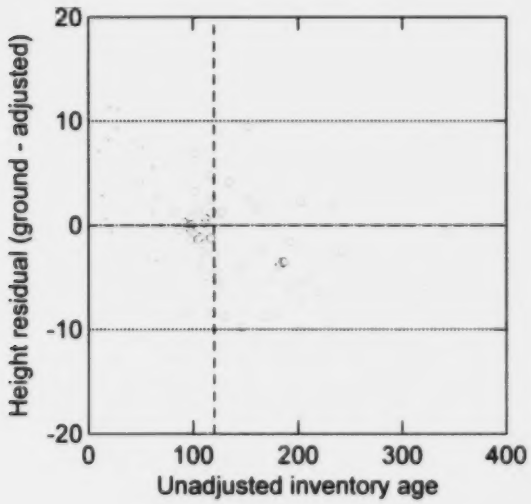


Fig 6: Height residuals (ground height – adjusted inventory height) as a function of inventory age for adjustments based on **Option 2** (immature & species substratification within mature) stratification. NOTE: **x**'s correspond to immature stratum samples and **o**'s correspond to mature stratum samples.



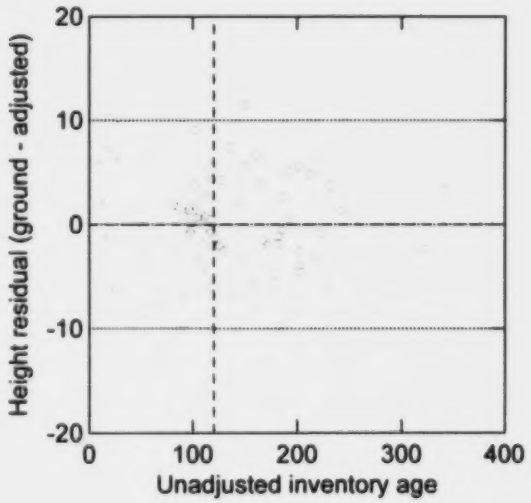


Fig 7: Height residuals (ground height – adjusted inventory height) as a function of inventory age for adjustments based on **Option 3** (single combined factor) stratification. NOTE: **x**'s correspond to immature stratum samples and **o**'s correspond to mature stratum samples.

Fig 8: Height residuals (ground height – adjusted inventory height) as a function of inventory age for adjustments based on **Option 4** (immature & age within species substratification for mature) stratification. NOTE: **x**'s correspond to immature stratum samples and **o**'s correspond to mature stratum samples.